Native grassland inventory and monitoring

Service Unit: Benton Lake NWR
Species or group: Upland habitat – Grasslands
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Abstract

Benton Lake refuge has nearly 6,000 acres of native western wheatgrass-green needlegrass prairie uplands. The NRCS has recently updated its guidelines to describe the species composition and structure of native prairie range types that are considered "healthy" and those that have crossed a threshhold and need significant management to restore function. We used these NRCS guidelines and protocols to establish pilot transects across the refuge. This pilot study was designed to assess the condition of refuge prairie, assess the effects of recent prescribed burns, assess the structural integrity of refuge prairie for nesting birds and create a pilot dataset from which to design long-term monitoring. We established 25 random transects across burn treatments (time-since-burn) throughout the refuge. On each transect we measured plant species composition, ground cover composition, litter depth, visual obstruction (VOR), vegetation height and took photos.

We documented 39 of an estimated 53 refuge plant species with these pilot transects. We found that although the refuge prairie is generally healthy, the data suggest native cool season grasses are being replaced with non-native, cool season grasses such as Japanese brome, cheatgrass and Kentucky bluegrass. In addition, there is significantly more bareground than NRCS recommends (34% instead of 5-15%). Forb and shrub composition is within NRCS guidelines. The recent early spring prescribed fires on the refuge did not appear to influence the native plant composition of our prairie. The pilot data suggest that there is a decrease in litter, plant height and plant vigor (measured by VOR) immediately after an early season prescribed fire, but this effect disappears by 2 years post-fire. Except for litter, which after the initial reduction, continues to increase each year after fire. In general, the structure of our native prairie meets the needs of many of our priority upland nesting birds. When litter depths are >6", it becomes less desirable for priority breeding birds and may be a good guideline for determining when to burn. Currently, refuge grasslands are short, sparse and lacking a significant litter layer, which is not ideal nesting habitat for several species of waterfowl.

Precipitation is likely to have the largest influence on the structure of our prairie. Recent prescribed fires appear to reduce litter, but do not seem to have had any other significant, lasting effects. Grazing might increase plant vigor, but until we have several more years of data, especially from wet years, it is not clear if the benefits would outweigh the costs. Chemical treatment of non-natives may be possible and could be explored further. The data from this pilot study should be used to help set specific goals and objectives during the CCP process. Once these have been defined, this pilot data can be used to design an effective monitoring plan that will provide feedback on health of refuge grasslands and whether or not objectives are being met.

Introduction

Benton Lake National Wildlife Refuge (refuge) was established in 1929 as a "refuge and breeding ground for birds". The refuge encompasses over 12,000 acres, approximately half of which is marsh and half is uplands. Of the almost 6,000 acres of uplands, nearly all is unbroken native prairie. The native prairie is a western wheatgrass-green needlegrass *Pascopyrum smithii* and *Nassella viridula* mixed-grass type (Hirsch et al 1995).

This western wheatgrass - needlegrass community is common across much of the northern Great Plains of the United States and Canada. Soils are fine-textured (clays, silty clays, clay loams, or rarely loams) and well-drained. (USFS 1992). This community usually occurs on level or nearly level ground but sometimes may be on moderate slopes of any aspect (Hirsch et al 1995).

The historic, western wheatgrass – needlegrass climax plant community (HCPC) is comprised of a mixture of tall and medium height cool and warm season grasses, native forbs and native shrubs. About 80% of the annual production is from grasses and grasslike plants, most of which are produced during the cool season. Forbs and shrubs contribute 15% and 5%, respectively to total annual production. (NRCS 2005).

Management of refuge grasslands has evolved since the refuge was established. Early on the refuge was regularly grazed by neighboring cooperators. However, in 1976 managers decided that grazing was not compatible with waterfowl production objectives and all grazing was eliminated (Benton Lake Annual Report 1976). Since that time, there has been no grazing on the refuge aside from native ungulates and an occasional trespass cow.

More recently, the refuge has used prescribed fire to manage native prairie. All of the refuge uplands have had an early spring prescribed burn within the last 5 years except the portion east of the Bootlegger Trail. For fire planning and management, the refuge has been divided into fire management units (Figure 1).

The refuge is fortunate that highly aggressive non-native plant invaders have not become established. Besides an occasional leafy spurge or spotted knapweed plant that is found and treated, and small infestations of Canada thistle, the refuge is free of noxious weeds. However, in recent years, concern over infestations of non-native Japanese brome, downy brome (cheatgrass), Kentucky bluegrass and crested wheatgrass on the refuge has increased.

The most recent plan for upland management states that the goal for managing the refuge's native prairie is to "maintain and manage 6000 acres of native refuge grasslands on a continuing basis for natural, native plant diversity [and health] and for the benefit of birds in their nesting and life requirements" (USFWS1997).

Since the refuge is beginning its Comprehensive Conservation Plan in 2008, and will be considering how to update these goals and set specific objectives, we developed this baseline inventory to understand the current composition and condition of the native grasslands on the refuge. We used the previously stated goals as general guidance and addressed the following objectives:

1. inventory native species
2. determine the condition of the grasslands (NRCS rangeland assessment)
3. assess effects on native grasslands of recent prescribed burn program on the refuge
4. assess structural integrity of grasslands for nesting birds (VOR, vegetation height, litter depth)
5. define inherent variation in dataset to better design long-term monitoring and assessment of refuge management activities, particularly prescribed fire

Methods

The basis for this analysis lies in the recently completed state and transition models developed by NRCS for range types in Montana (NRCS 2005). Grasslands are dynamic systems that do not proceed in a linear manner from early succession to a climax community. These NRCS models describe the vegetation dynamics in a way that recognizes the non-linear nature of grasslands. For each grassland type, "states" are identified that describe the variations of community composition and structure that have been observed by field experts. Changes in vegetative states are "transitions" which are triggered by precipitation, fire and grazing. Each of the models identifies a reference state, which describes the natural range in variation of plant community composition and structure that results from transitions. Outside of this reference state, a "threshold" is crossed where plant community composition and structure has changed enough that it will require significant management inputs to transition back to the reference state.

An example of the state and transition diagram for clayey range types at Benton Lake is in Appendix A. Clayey is the predominant range type on the refuge (~90%) (Figure 2) and is one range type found within the western-wheatgrass-needlegrass community type (Siddoway 1993). Full descriptions for range types in our zone can be found at http://efotg.nrcs.usda.gov under "Ecological Site Descriptions".

Our plant sampling methodology was adapted from NRCS's rangeland assessment protocol. This method is a point-intercept method. In 2006, we randomly established seventeen 100ft long transects stratified by fire management units. The transects were laid out at 270° from each starting point. Permanent rebar with yellow plastic caps were placed at the start and end of each transect and a 100' tape was stretched between them. At each 1' mark, a pin flag is used to identify all of the vegetation layers and composition (up to 3 canopy levels). Photos are also taken over a 1ft sq frame at the 10, 30, 50, 70 and 90' marks. A tennis ball and golf ball (or other markers) were placed in the photo for scale reference.

In 2007, we collected visual obstruction (VOR), litter depth and vegetation height measurements at the 0, 50' and 100' point on each transect. A Robel pole was used to measure the VOR in the four cardinal directions, rounded to the nearest half decimeter and then averaged for each point and the transect (Robel et al 1970). Vegetation height was measured by visually identifying the tallest vegetation within 3' of the pole and rounding the height to the nearest half decimeter. To measure litter depth, a reading to the nearest centimeter was taken on opposite sides of the Robel pole and averaged at each location.

The refuge uplands are divided into six burn management units, each with several sub-units (Figure 1). We stratified the random transects by burn sub-unit. In 2006, when we collected the vegetation composition data, we had transects in units burned earlier the same year, 1 year post-fire, 2 years post-fire or >5years post fire (Figure 1). In 2007, Unit 6 was burned during March so we had transects in sub-units that were same year, 1 year, 2 years, 3 years and >5 years post-fire.

Total plant species richness on the refuge was estimated using the program EstimateS (Colwell 2005).). Initial runs of EstimateS found the coefficient of variation was greater than 0.5. Based on this, we re-ran the program using the 'Classic' instead of the 'Bias-corrected' option, compared the results of the ICE (53spp) or Chao2 estimator (47spp), and chose the larger ICE (Coldwell 2005). We initially plotted the ICE values against the species observed curve, but found that the second order Jackknife estimator gave the same total species estimate (53) but was a smoother curve (Figure 3) (Burnham and Overton 1979, Palmer 1991, Colwell and Coddington 1994, Chazdon et al 1998).

The 17 transects analyzed and discussed in this report are all located on clayey soils (range type) on the refuge. Our sampling, inferences and this report are limited to these areas of the refuge. We did collect data on two transects in the silty and silty-steep range types east of the Bootlegger. We also sampled 8 additional transects to estimate variation between transects within a given management unit. We placed 4 of these in a unit burned earlier that spring and 4 in a unit burned >5 years ago. This additional data is not discussed here but will be useful in designing a monitoring program for the refuge grasslands.

Results

Individual plant species encountered on transects are listed in Appendix B. We documented 39 species over 25 transects (Figure 3).

The historic climax western wheatgrass-green needlegrass plant community on clayey soils should be comprised of about 80% tall and medium height cool and warm season grasses, 15% forbs, and 5% shrub (NRCS 2005). We assumed that values within 5% of these suggested benchmarks were reasonable. Four transects had 80 ± 5% native grass, however, the rest of the transects were below this range (Figure 4a). Almost all of the native grass component on transects were comprised of cool season grasses, only two transects had more than 10% warm season. On most of the transects, the percentage of native forbs were within the ideal 15±5% of the total composition (Figure 4b). The only transect where we found more than this was in an area burned earlier that spring (29% forbs), four transects had less than 10% forbs. Two of these were burned 1 year earlier and 2 were burned more than 5 years ago. A majority of the transects had shrub compositions within 5±5% of total composition (Figure 4c). No transects burned within 1 year had shrub composition higher than 10%. Six transects with shrub composition greater than 10% were either 2 years post-burn or >5 years. However, two transects in the area that had not been burned in at least 5 years had 0% shrubs.

Several transects had non-native species present. Ideally, there would be no non-natives, but at least <10% of the total composition is still considered within the reference state (Siddoway, pers comm.). Five transects had >10% non-natives and were found within the 0, 2 and >5 years-since-fire management units (Figure 4d). On transects where native grasses are <75%, they appear to be replaced with non-native grasses. Non-native species most commonly detected on transects include Japanese brome, downy brome, Kentucky bluegrass and crested wheatgrass.

According to the NRCS reference state guidelines for the western wheatgrass-green needlegrass clayey range type, bareground should be 5% - 15%, of the total ground cover composition. All transects were above this range and the average was 34% ± 7.6. There are no quantitative NRCS guidelines for litter or vegetation ground cover, however we plotted these against years-since-fire to look for trends (Figure 5).

Average vegetation height among transects and years-since-fire was between 4 and 5dm (Figure 6). Mean visual obstruction readings varied from 0.17dm to 0.44dm and the data suggest a trend of increasing VOR with time since fire (Figure 7). Litter depth varied from 2.1cm to nearly 8cm, and again, there appears to be an increasing trend in litter depth with time since fire (Figure 8).

Discussion

These pilot vegetation transects were effective at detecting many of the plants we would expect at the refuge. We detected 39 of an estimated 53 species (Coldwell 2005). Additional species can be added to the refuge list over time through incidental observations. We would also like to establish an herbarium collection for the refuge. A storage cabinet already exists in the office basement, some additional materials and staff time to collect plants would complete this project.

As compared to NRCS' state-and-transition models for refuge grassland types, the native prairie is generally in a healthy state (reference state). However, several deviations from the reference state are cause for concern. The mean percentage of bareground (34%) is well above the 5-15% recommended for this range type. Beside mechanisms that may remove litter, such as wind or fire, the higher percentage of bareground may be a result of reduced above ground primary production. In other words, the plants are not numerous enough or large enough to fill in the available space and there is not enough plant material to create sufficient litter to cover the ground. Furthermore, these pilot data suggest that where native grasses are below the recommended 80% of the total composition, non-native grass species have replaced them. These factors together may be telling us something important about the health of our prairie.

The transitional drivers of this type of grassland systems described by NRCS include precipitation, fire and grazing (NRCS 2005). It may be that the presence, absence or quality of one of these drivers has resulted in higher than normal amounts of bareground and/or increases in non-native grasses. If so, changes in management strategies may improve the overall health of refuge grasslands.

Of the three drivers, precipitation may be the most influential on above ground production. We get most of our precipitation during the spring (Apr-June). For the 10 years prior to sampling, we had below normal spring precipitation for 6 (WRCC 2007). Other studies from Montana have found that experimentally created spring droughts can reduce total above ground production 20-40% (Heitschmidt et al 2005) and across the west, as much as 90% of the variation in above-ground primary production can be explained by precipitation alone (Sims and Singh 1978, Sala et al 1988). Clearly, however, precipitation is not something that can be changed or affected through management. It may be that the higher percentage of bareground is simply a result of natural precipitation conditions and does not require any change in management.

Fortunately, Heitschmidt et al (2005) also found that grasslands realized nearly full recovery within 2 years post-drought. Unfortunately, the non-native grasses may also be favored during years of higher precipitation. Kentucky bluegrass, Japanese brome and cheatgrass are all favored by moist conditions (Sather

1996, Mosley et al 1999, Haferkamp and MacNeil 2004). Kentucky bluegrass may be significantly reduced during drought conditions (Siddoway, pers comm.) but Japanese brome and cheatgrass are viable over a wide range of conditions (Haferkamp and MacNeil 2004). The higher than desirable levels of non-natives within refuge grasslands, despite 6 of 10 years with below normal precipitation, indicates that simply waiting for dry years likely will not be enough to control these invaders.

The natural fire interval for northern mixed grass prairie in our area is estimated to be 10-12 years (NRCS 2005) and presumably most historic fires would have occurred during the dry, hot summer and early fall months. As described in the methods section, much of the refuge has been subject to early spring (Feb-Mar) prescribed burns during the last 4 years.

Our pilot data do not suggest that percent bareground, native or non-native grass composition varies in any predictable way with the time since a prescribed fire. The cool and moist conditions during spring burns create a mosaic of burned and unburned areas, which may explain the variability in our results. Also, casual observation suggests that the prairie on the south and west sides of the refuge is more heavily invaded with non-natives. It may be that the effects of fire is masked by the location of the transects. We can reduce variability in the data in future years if we revisit the same transects. The number of additional transects, and/or changes to our protocol, that would be needed to detect any significant trends with prescribed fire can be discussed during design of our long-term monitoring program after specific goals and objectives have been defined in the Habitat Management Plan.

Alternatively, instead of putting out more transects to detect a potentially minor effect, we should investigate whether we can change our prescribed fire management to elicit a stronger, desired response. This is especially true since prescribed burning requires a significant investment of refuge resources. The timing of burns, in particular, could be critical for increasing native plant vigor (reducing bareground) and for reducing non-natives.

The green-needlegrass/western wheatgrass range type that occurs on the refuge is dominated by cool season grasses. In fact, a transition to dominance by warm season grasses is considered an indicator of a pre-threshold community and decreased health (NRCS 2005). Burning during the period of initiation or active growth of the cool season dominants, late Apr-Jun, would be detrimental to these species and is not recommended (Higgins et al 1989).

Unfortunately, the potential benefit of prescribed fire at other times for these two dominant species is not clear from a review of the literature. Western wheatgrass does not seem to be strongly affected, either negatively or positively, by timing of prescribed burns (White and Currie 1983, Tirmenstein 1999). Green needlegrass has also displayed a variety of responses to fire. However, there have been at least a few studies that found spring and fall burning is detrimental to green needlegrass (Dix 1960, Taylor 2001) and have even considered green needlegrass intolerant to spring burning (Whisenant and Uresk 1990).

In our initial pilot transects, the VOR, which could be used as an indirect measure of plant vigor (Robel et al 1970), suggest a decrease in the season immediately following early spring prescribed fire. This effect disappears by year 2 post fire. Understanding the effect of timing of fire on native species on the refuge may require our own experimentation.

The pilot data do not suggest any effect of our early spring prescribed fires and percent composition of non-natives. Unfortunately, the non-natives we would like to control, Kentucky bluegrass, Japanese brome, crested wheatgrass and cheatgrass, are actively growing at essentially the same time as our desirable native grasses. Late spring burning to reduce Kentucky bluegrass will commonly reduce green needlegrass at the same time (Higgins et al 1989). Spring burning has not be found to be effective for controlling Japanese brome and produces mixed results for cheatgrass, which may instead significantly increase under these conditions (Higgins et al 1989, Howard 1994). In a separate study on the refuge, we found that early spring fire may be stimulating seed production in crested wheatgrass stands (USFWS 2008). Crested wheatgrass is quite resilient to fire and burning during its dormant stage (early spring or fall) can stimulate growth (Zlatnik 1999). Late summer or fall burning has not been tested for Kentucky bluegrass (Sather 1996), but has been shown to be effective for Japanese brome and cheatgrass (Higgins et al 1989, Howard 1994). Late-summer and fall burning for cheatgrass must be approached with caution because it is highly flammable (Higgins et al 1989). Follow-up monitoring will be needed to assess the role fire has in controlling non-native species on the refuge.

Grazing was removed from the refuge in the late 1970s because it was considered to be in conflict with wildlife productivity goals (Benton Lake Annual Report, 1976). It is difficult to know if the grassland conditions we see today are a result of that intense grazing period or the last 30 years of rest.

There is much controversy over the effects of grazing on plant productivity and species composition, but much agreement that it is secondary to the stronger and dwarfing effect of precipitation (Briske 1993, Painter and Belsky 1993, Dyer et al 1993, Biondini et al 1998). In the northern great plains in particular, the effect of grazing on plant structure, composition and above ground production varies with timing of grazing and is highly interactive with precipitation (Heitschmidt et al 2005).

Using grazing to control non-native grasses is also problematic. Japanese brome, downy brome and Kentucky bluegrass are all quite resilient to defoliation and, as with fire, effective spring grazing could also negatively affect the native cool season plants (Carpenter and Murray 1999, Haferkamp and Karl 1999, Sather 1996). Based on the available research, it is difficult to predict if reinstating a grazing program on the refuge would benefit the grasslands enough to warrant the additional money and staff resources this would require.

Anecdotally, we have observed microsites with disturbance from burrowing animals, such as mounds around badger holes, with much larger and more vigorous plants than undisturbed areas nearby. Also, we have observed several native bunch grass plants that are dead in the center, indicating reduced vigor (J. Siddoway, pers comm.). A fenceline contrast in the area east of the Bootlegger shows several brome dominated areas on the refuge and apparent absence of non-natives on the neighbor's grazed pasture (Figure 9).

Figure 9. These two photos were taken from the same location on the fence between the refuge (to the north) and the neighbor (to the south). The photo on the left is the refuge where the tannish-orange color is non-native Japanese brome and cheatgrass. The neighbor's land (right) appears to have very little invasion by these species.

Herbicides could be considered, in combination with other management activities, to assist in non-native grass control. However, this will also be difficult because Japanese brome, cheatgrass and Kentucky bluegrass are not present in monotypic stands on the refuge, but grow intermingled with native species. This makes avoiding non-target species, especially when both are growing in the spring, more difficult. Careful fall application may be helpful in reducing total composition of non-natives, but some plants will likely survive until spring and produce seeds, making complete eradication difficult (Sather 1996, Carpenter and Murray 1999). Crested wheatgrass does occur in monotypic stands on the refuge and efforts to control this species with glyphosate are scheduled to begin in 2008.

Comparing our pilot data for vegetation height, litter depth and visual obstruction (VOR) with known nesting preferences for refuge priority bird species is also informative for setting goals and objectives for our grasslands (Wiens 1973, Dieni and Jones 2003, Fondell and Ball 2004). We have identified several priority bird species that breed in the grasslands by comparing lists of species that occur on the refuge with national and regional bird priorities (Table 1). The specific microhabitat nesting requirements for most of these species have already been compiled in biological assessments prepared for other refuges (Laubhan et al 2006).

The range of vegetation heights and litter depths we recorded on the refuge include the preferences of almost all of the priority species (Laubhan et al 2006) (Figure 10). Interestingly, a VOR of 2dm is often recommended as ideal or a "rule of thumb" for nesting waterfowl (Baldassarre and Bolen 2006), but the average reading on our native transects was well below this (<0.4dm) (Figure 4). NRCS describes the potential production of this range type as 1300lbs/acre, which translates to a VOR of about 1.3dm (NRCS 2005, Robel et al 1970). Not surprisingly, the birds we most commonly see during the breeding season on the refuge coincide with nesting preferences that include VORs <0.4dm. Gadwall have consistently been the most common duck during waterfowl surveys and chestnut-collared longspurs were the most common grassland bird detected during 4 years of grassland point counts on the refuge (USFWS, *unpubl data*). This should be monitored over several years to determine how much this value may vary with annual precipitation.

Our pilot data suggest that these factors may be influenced by prescribed fire. In the year immediately after an early–spring burn, VOR, litter depth and vegetation height appear to be reduced. The effect appears to disappear in year 2 and level out for VOR and vegetation height, but litter depth appears to continue to increase with each year after fire (Figure 6-8). A range of litter depths from 0-6cm encompasses the nesting preferences of our priority bird species (Laubhan et al 2006). Litter depths that exceed 6cm are beyond the range of nesting preferences and may serve as an indicator of the need for a prescribed fire.

Summary and Management Recommendations

Since this is an initial pilot study, it is not intended to be the basis for any strong management recommendations. However, some interesting trends and potential direction can be derived from this data. The native grasslands on the refuge appear to be generally healthy. Where we see deviations from the reference state, it appears the native cool season grasses are being replaced by non-native cool season grasses. There is also significantly more bareground than considered ideal for our range type.

The recent early spring prescribed fires on the refuge did not appear to influence the native plant composition of our prairie. These fires did not appear to reduce non-native grasses, and may increase the spread of cheatgrass. The data suggest that there is a decrease in litter, plant height and plant vigor (measured by VOR) immediately after an early season prescribed fire, but this effect disappears by 2 years post-fire except for litter, which after the initial reduction, continues to increase each year after fire.

In general, the structure of our native prairie meets the needs of many of our priority upland nesting birds. When litter depths are >6”, it becomes less desirable for priority breeding birds and may be a good guideline for determining when to burn. Refuge grasslands are short, sparse and lacking a significant litter layer, which is not ideal nesting habitat for several species of waterfowl.

Precipitation is likely to have the largest influence on the structure of our prairie. Prescribed fire appears to reduce litter, but does not seem to have any other significant, lasting effects. Grazing might increase plant vigor, but until we have several more years of data, especially from wet years, it is not clear if the benefits would outweigh the costs. Chemical treatment of non-natives may be possible and should be explored further.

The data from this pilot study should be used to help set specific goals and objectives during the CCP process. Once these have been defined, this pilot data can be used to design an effective monitoring plan that will provide feedback on health of refuge grasslands and whether or not objectives are being met.

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Figure 1. Refuge fire management units and year they were most recently burned. Locations of vegetation transects are also shown.

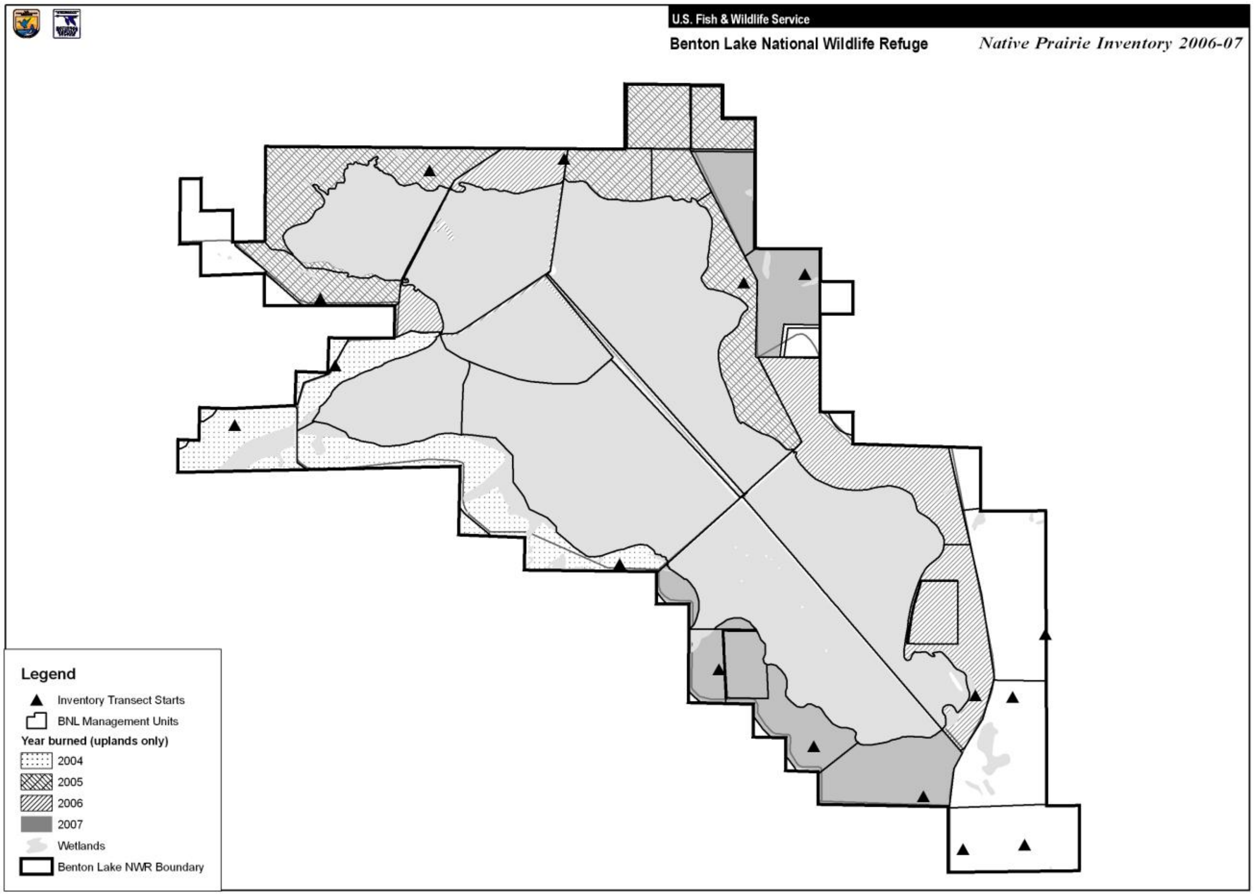
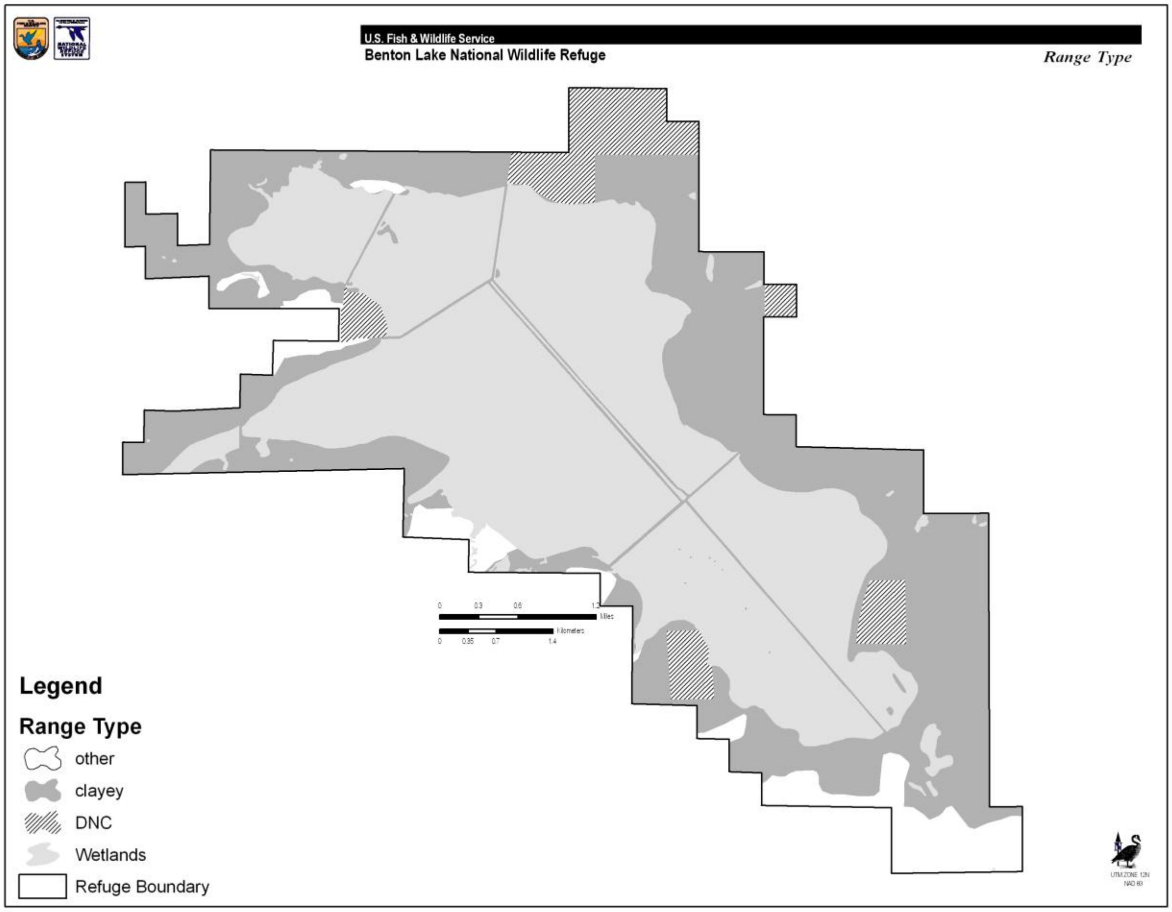


Figure 2. Range types on the refuge defined during an NRCS range survey in 1993. The majority of the refuge is Clayey 10-14" p.z.



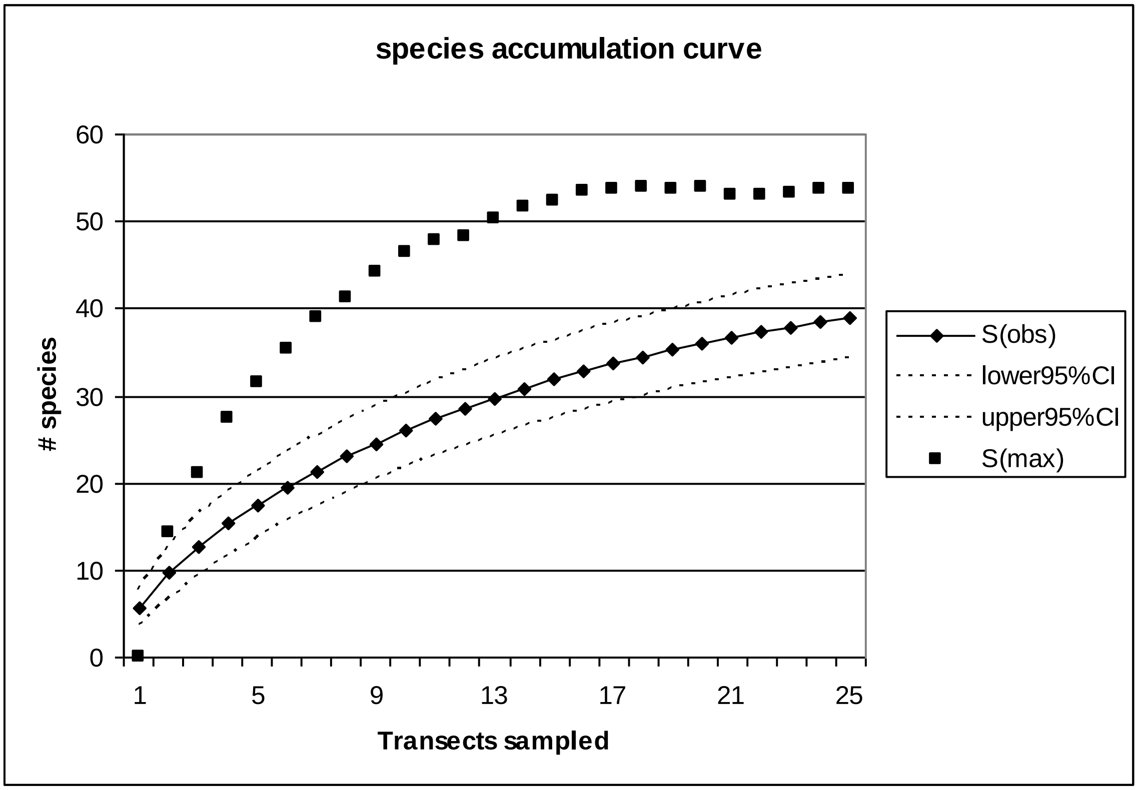


Figure 3. Estimate of total plant species richness for Benton Lake NWR. The lower line S(obs) shows the observed number of species accumulated over 25 transects with 95% confidence intervals. The upper line, S(max), is the estimated total number of species (Jack2, Coldwell 2005). Over a total of 25 pooled samples, the estimated total species richness is 53.

Figure 4a-d. Plant composition on pilot transects (grouped by years-since-fire) relative to the reference state (NRCS 2005) . Figure 4(a) shows the percentage of native grasses found on each transect relative to the recommended 80±5%, shown by the gray bar. Figure 4(b) shows the percentage of native forbs found on each transect relative to the recommended 15±5%, shown by the gray bar. Figure 4(c) shows the percentage of native shrubs found on each transect relative to the recommended 5±5%, shown by the gray bar. Figure 4(d) shows the percentage of non-natives found on each transect relative to the recommended <10%, shown by the gray bar.

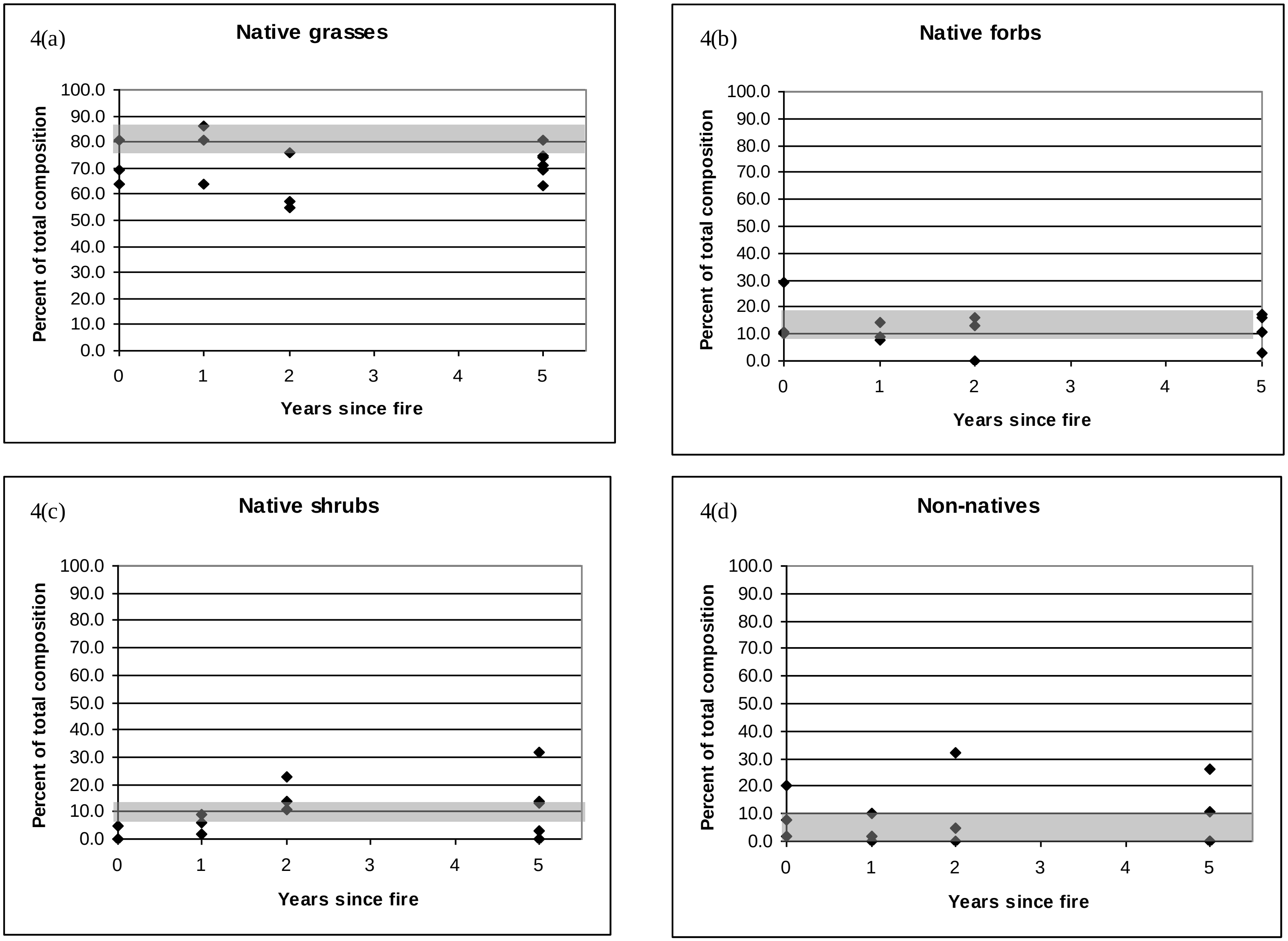
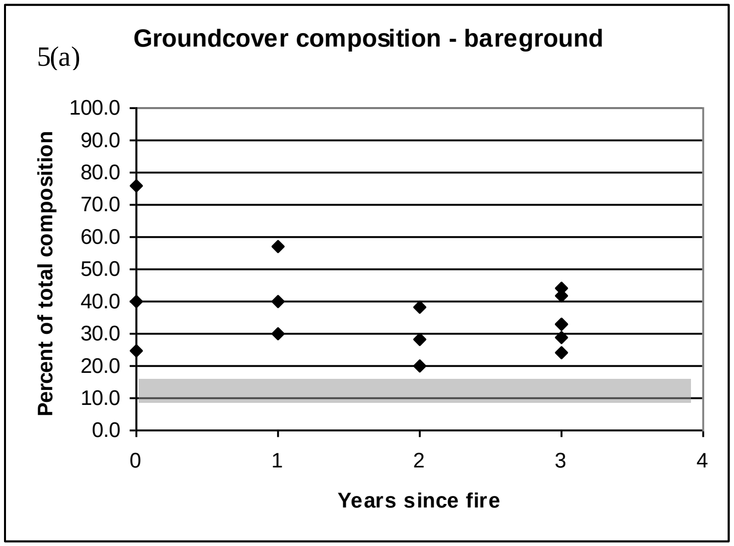
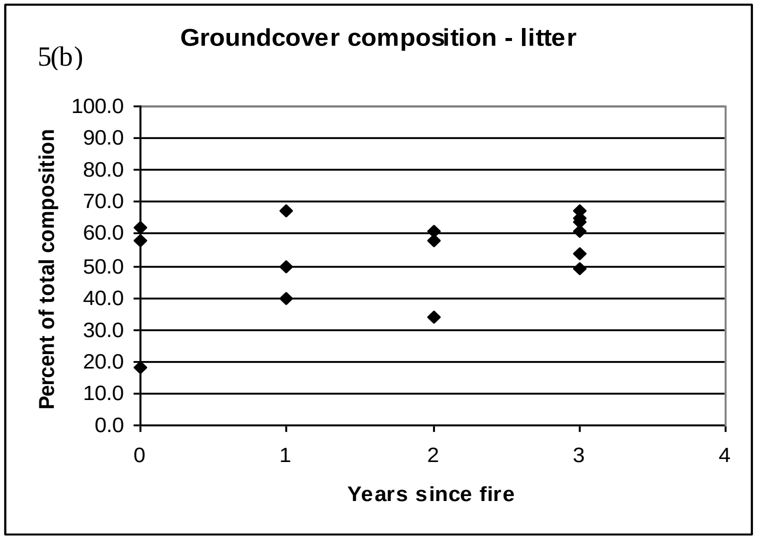


Figure 5a-c. Ground cover composition on pilot transects (grouped by years-since-fire) relative to the reference state (NRCS 2005) . Figure 4(a) shows the percentage of bareground found on each transect relative to the recommended 10±5%, shown by the gray bar. Figure 4(b) shows the percentage of ground covered by litter on each transect. Figure 4(c) shows the percentage of ground covered by live vegetation on each transect.





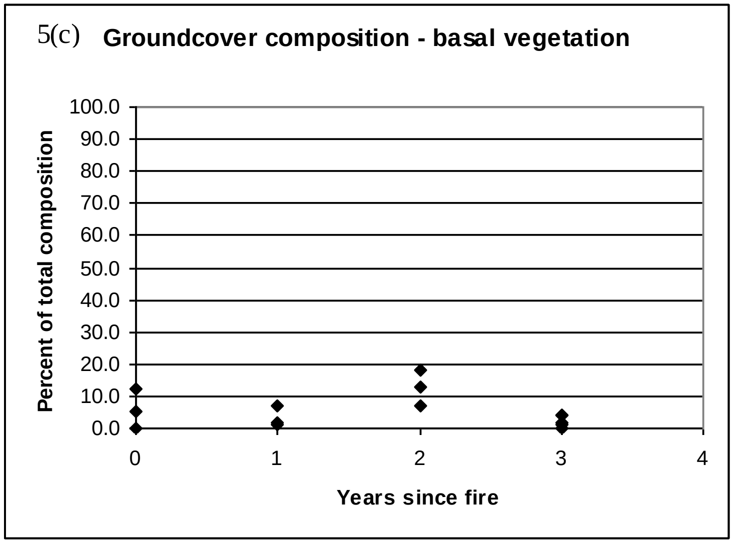


Figure 6. Mean vegetation height for transects grouped by years-since-fire.

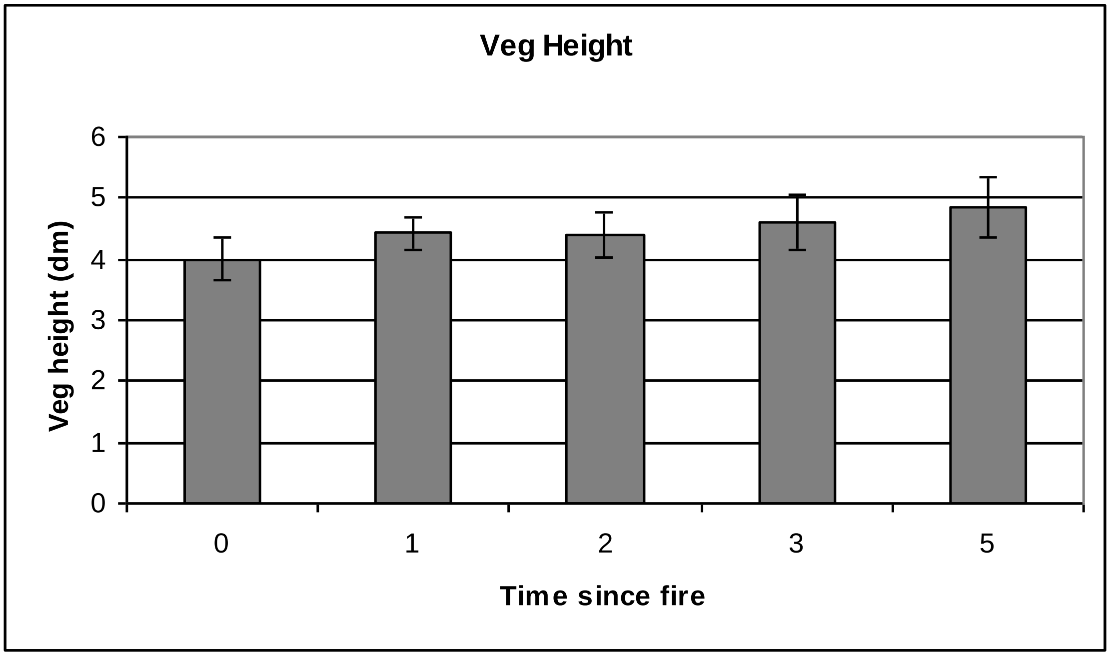


Figure 7. Mean visual obstruction reading for transects grouped by years-since-fire

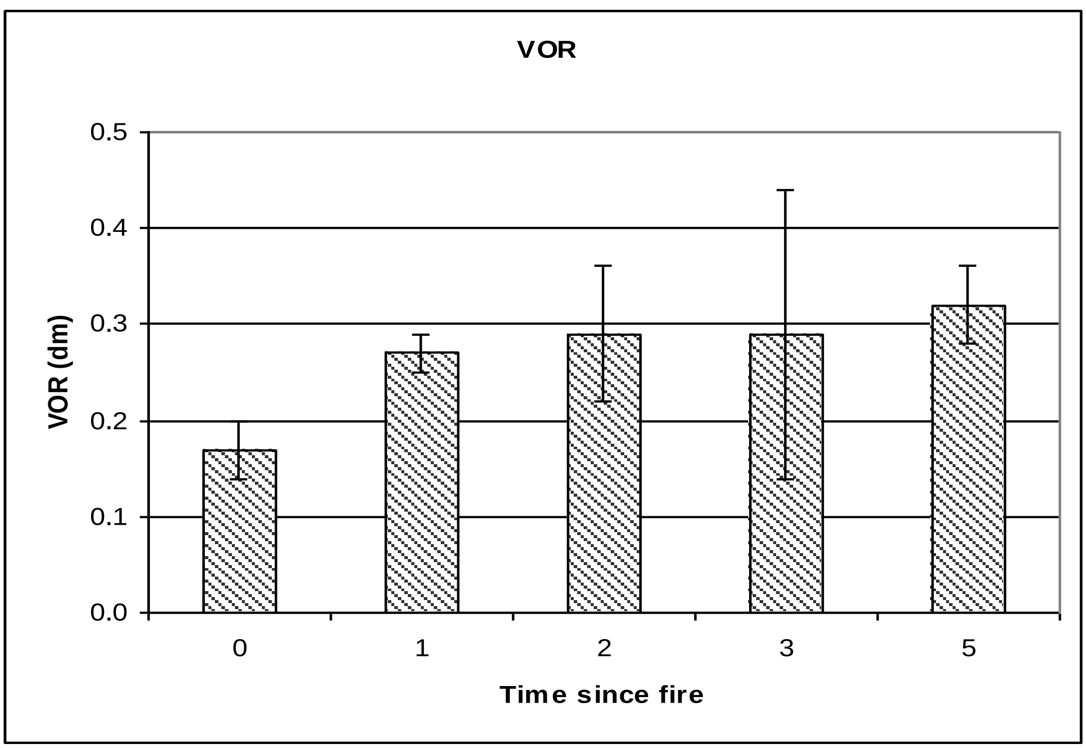


Figure 8. Mean litter depth for transects grouped by years-since-fire

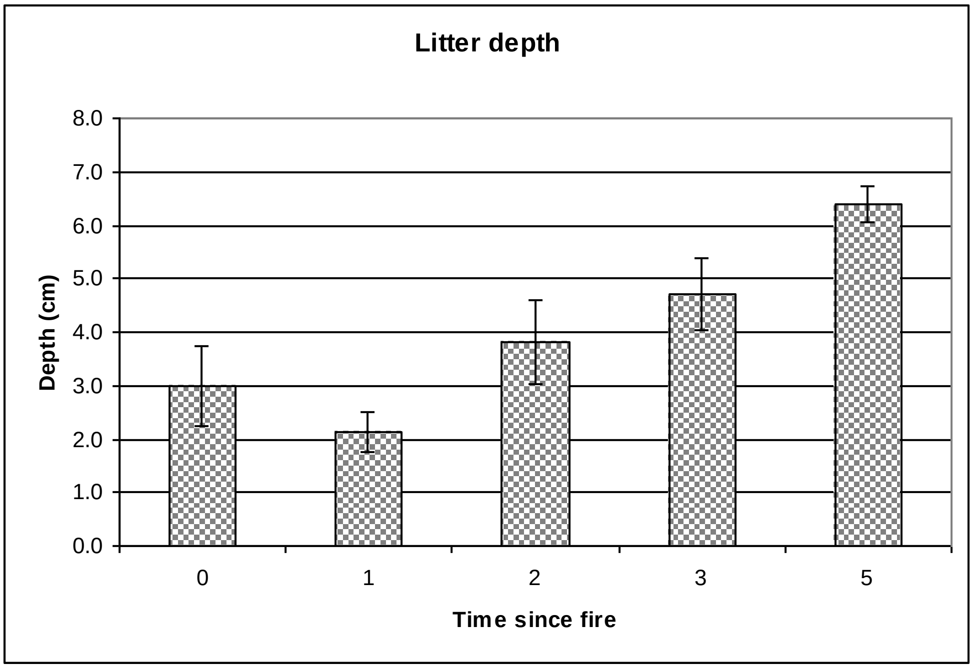


Figure 10. Range of visual obstruction values preferred by refuge priority grassland breeding birds. The gray shaded area shows the range of VOR values recorded on refuge transects, with the mean shown by the dashed line.

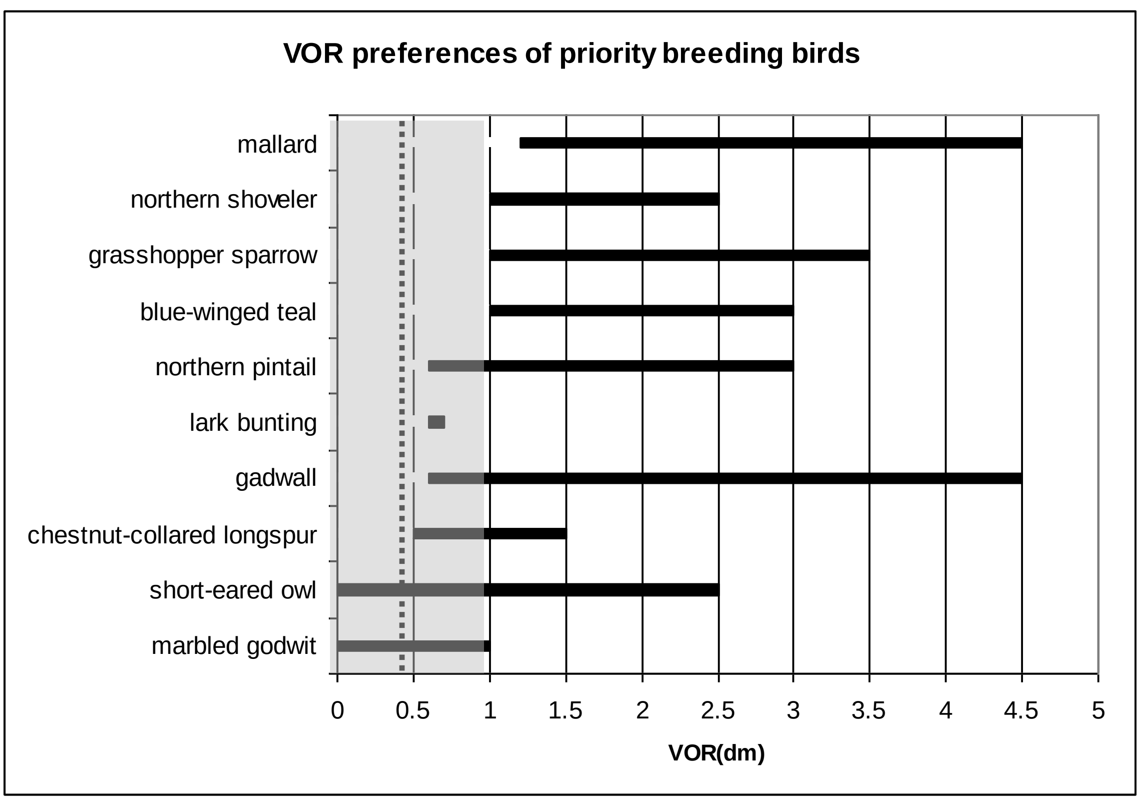
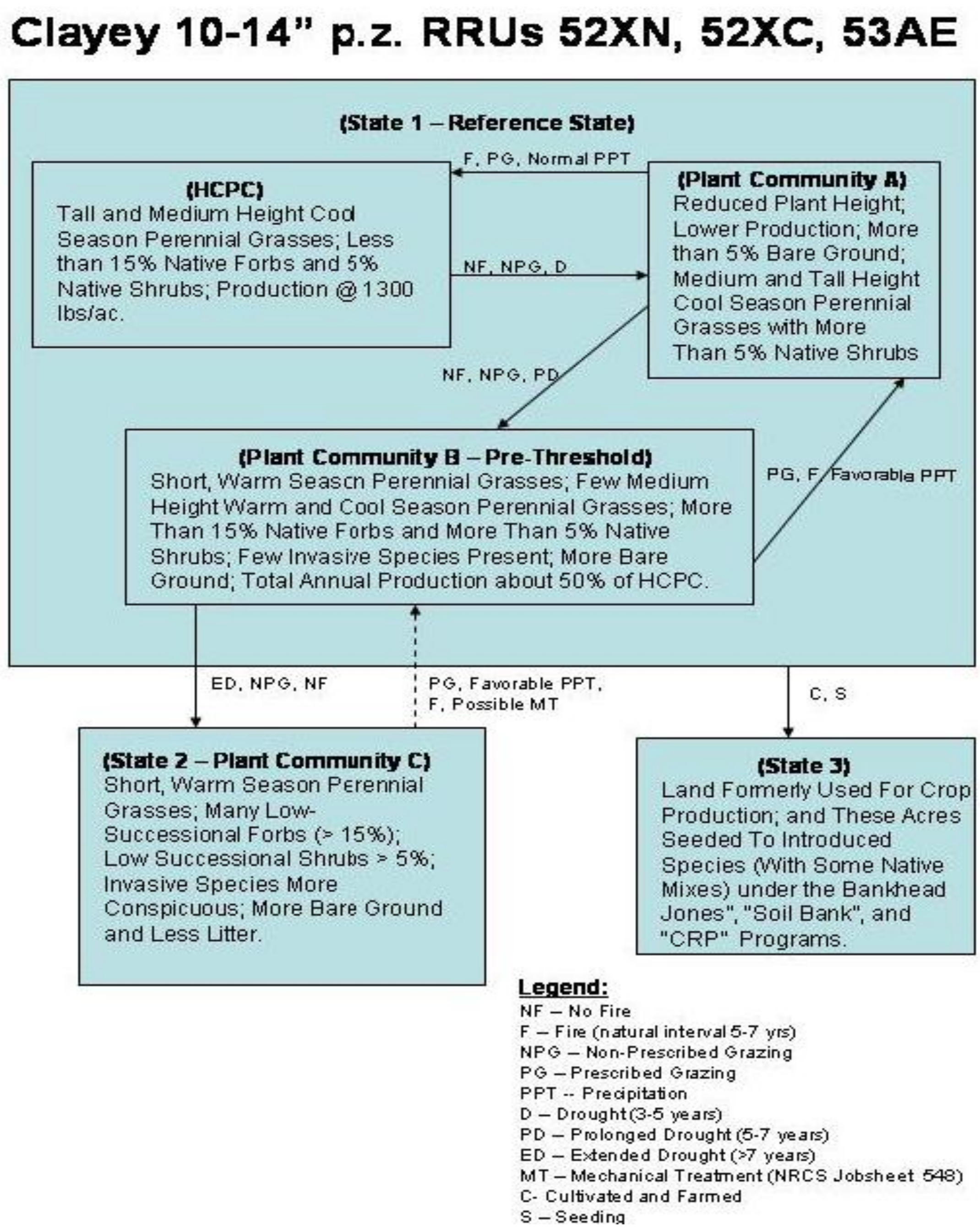


Table 1. Summary of birds that nest in grasslands at Benton Lake refuge that are a species of concern or priority at the regional or national level.

Common name	*BCC/NAWMP BCR11*[a]	*MIGBIRD Focal Spp*[b]	*US Shorebird Plan*[c]	*PIF*[d]
gadwall	**x**			
American wigeon		**x**		
mallard	**x**	**x**		
blue-winged teal	**x**			
northern shoveler	**x**			
northern pintail	**x**	**x**		
green-winged teal	**x**			
ferruginous hawk	**x**	**x**		
long-billed curlew	**x**	**x**	x	
marbled godwit	**x**	**x**	**x**	
burrowing owl	**x**	**x**		
short-eared owl	**x**	**x**		X
lark bunting				x
grasshopper sparrow	**x**	**x**		x
Baird's sparrow	**x**	**x**		X
McCown's longspur	**x**			
chestnut-collared longspur	**x**	**x**		

(a) Birds of Conservation Concern (USFWS 2002) and/or North American Waterfowl Management Plan (USFWS 1998) (b) USFWS Migratory Bird Program Focal Species (USFWS 2005) (c) US Shorebird Plan priority species (Brown et al 2001) (d) Partners in Flight species of concern (Rich et al 2004)

Appendix A. Example of NRCS State and Transition Model



APPENDIX B. LIST OF PLANT SPECIES DETECTED IN NATIVE GRASSLAND SURVEYS AT BENTON LAKE NATIONAL WILDLIFE REFUGE

Native grasses	
bluebunch wheatgrass	*Agropyron spicatum*
green needlegrass	*Stipa viridula*
needle and thread	*Stipa comata*
needle leaf sedge	*Carex eleocharis*
prairie junegrass	*Koeleria macrantha*
western wheatgrass	*Agropyron smithii*
blue grama	*Bouteloua gracilis*
Sandberg’s bluegrass	*Poa secunda*
Native forbs	
American vetch	*Vicia americana*
bahai	*Picradeniopsis oppositifolia*
biscuit root	*Lomatium macrocarpum*
clubmoss	*Salaginella densa*
field chickweed	*Cerastium arvense*
golden pea	*Thermopsis rhombifolia*
ground plum milk vetch	*Astragalus crassicarpus*
hairy goldaster	*Chrysopsis villosa*
heath aster	*Aster ericoides*
hood's phlox	*Phlox hoodii*
pussy toes	*Antennaria neglecta*
scarlet globemallow	*Sphaeralcea coccinea*
twin arnica	*Arnica sororia*
western yarrow	*Achillea millefolium*
wild onion	*Allium textile*
Native shrubs	
broom snakeweed	*Gutierrezia sarothrae*
fringed sagewort	*Artemesia frigida*
Nuttal's saltbush	*Atriplex nutallii*
prickly pear cactus	*Opuntia polyacantha*
rabbit brush	*Chrysothamnus nauseosus*
Non-natives	
Kentucky bluegrass	*Poa pratensis*
cheatgrass	*Bromus tectorum*
crested wheatgrass	*Agropyron cristatum*
Japanese brome	*Bromus japonicus*
salsify	*Tragopogon dubius*
dandelion	*Taraxacum officinale*
yellow alyssum	*Alyssum simplex*